1,104,746

PATENT SPECIFICATION

DRAWINGS ATTACHED

1,104,746

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Int. Cl.:— B 61 b 13/12

COMPLETE SPECIFICATION

Transport System

I, JOHN ALLAN, a British subject, of Elveley, West Drive, Sonning, Berkshire, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to transport systems and is especially concerned with a transport system wherein a train of one or more passenger or freight-carrying cars is propelled between two vertically spaced apart continuous stationary rails, for instance an overhead railway.

Hitherto overhead railways have been proposed of the monorail type, and there are, basically speaking, two kinds of monorail railway, viz the suspended kind, in which the cars hang from an overhead rail, and the supported kind, in which the cars straddle the rail. Both of these basic types can be mounted at varying heights above the ground and they are able to accommodate reasonably sharp curves and steep gradients. They are propelled either by a self-contained diesel engine or by electric power picked up from a conductor rail in the track.

It is the object of the present invention to provide a new transport system by means of which passengers and freight may be transported in cars or vehicles which may travel at high speeds between two stationary rails.

According to the present invention a transport system comprises at least one vehicle, a lower continuous rail and an upper continuous rail vertically spaced apart and between which the vehicle is mounted for longitudinal movement, at least one centrally disposed lower bogie provided on the vehicle and having at least one wheel adapted to ride along the lower continuous rail and wheels arranged to engage opposite vertical sides of said lower rail to provide guidance for the vehicle, and at least one centrally disposed upper bogie provided on the vehicle and having wheels arranged to engage opposite vertical sides of the upper continuous rail to provide guidance for the vehicle, the lower and upper bogies being adapted to become electro-magnetically coupled with the lower and upper continuous rails respectively when alternating electric current is supplied to the bogies or parts thereof to form linear induction motors for the propulsion of the vehicle.

The lower continuous rail may be situated in a channel and the channel may form part of a conduit of, for instance, circular or trapezoidal cross section. When this rail is situated in a conduit, this will completely enclose the vehicles except at locations in the system where stations for the transfer of passengers or freight are desired. Both the upper and lower continuous rails will be mounted on the inside surface of the conduit, and will be diametrically opposed. The channel or conduit may be mounted on pylons above the ground or it may be laid at ground level. When a conduit is employed, completely enclosing the vehicles, it may be situated underground or even under the sea.

The system of this invention may comprise any number of vehicles, and usually will comprise a leading vehicle, hereinafter termed a fan car, coupled to several other vehicles in the form of a train. The fan car may provide additional driving means for the train, or it may simply be used to pass air from the front of the train over the train.

In a particular preferred embodiment of the invention the vehicle or vehicles comprising the train will be supported on a cushion of air, and it is envisaged that the cushion of air will be used for long journeys of the train, particularly at high speeds, the feature of the lower bogie wheel which rides on the lower continuous rail being used when the train is adapted to travel short distances, at low speeds, and also when the train is slowing

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down from its high-speed air-cushion travel. The air for the cushion is taken from the front of the train by means of an electric powered fan system in the fan car, or in the single vehicle when only one vehicle is used, which fan system draws air from the front and passes this through a duct or ducts extending beneath the vehicle or vehicles. The fan system may also comprise a second fan means adapted to pass excess air, i.e. air not used for the supporting air cushion, to the rear of the train. Thus, contrary to what might be expected, the passage of a train through a conduit, according to this invention, will not move a column of air before it, as the fan system is so controlled as to consume air from the front at a rate proportional to the forward speed and to pass a quantity of it through ducts extending beneath the train. Each duct may have a series of air outlets, or a single extended outlet. Preferably the air cushion is retained by parallel shelves running the length of the channel or conduit at approximately the level of the top face of the lower continuous rail. Further retention of the supporting air cushion may be provided by flexible skirts arranged at the front and rear of the train, the skirts being tailored to the internal transverse configuration of the channel or conduit between the shelves. Preferably the air cushion is produced by means of a duct situated on each side of the lower bogies and extending the length of the train.

The pressure in the ducts is maintained at a level superior to that of the air cushion and is preferably discharged through nozzles via restrictor valves so that it impinges on the upper faces of the shelves. As mentioned above, any air which is not discharged is ejected at the rear of the train, through a pressure maintaining valve. The second fan serves to boost the passage of air over the sides and top of the vehicle. Preferably the ducts comprise nozzle arms which are flexibly mounted about longitudinal axes, and comprise a number of discrete segments individually free to move but sealed to each other. Restraint to the nozzle arms in a downward direction causes the nozzle gap to increase should the vehicle rise above normal level, so allowing expulsion of cushion air. Should the vehicle sag, however, the nozzles maintain the proper gap at the shelves and the rotation of the nozzle arms causes the opening of valves in the under surface of the duct to allow rapid discharge of high pressure air directly into the cushion. The advantage of making the air ducts in the form of a number of short segments is that not only is control provided for the riding level of the vehicle independent of its loading, but control of pitch is arranged from the localised nature of the system.

As hereinbefore mentioned, the vehicle or vehicles forming the train is or are propelled by means of linear induction motors, the "rotor" components thereof being the upper and lower continuous rails. The "stator" components, which are arranged electromagnetically to engage the rotor components, are provided on or by the upper and lower bogies. It will be appreciated that the thrust of the linear induction motors is above and below each vehicle, and this will produce a resultant thrust parallel to the axis of the channel or conduit and approximately through the loaded centre of gravity of the vehicle. By this means pitch induced by acceleration or braking is minimised.

The stator units may be provided by the upper and lower bogies being in the form of electromagnets of substantially horseshoe section, or alternatively by electromagnets of such section being provided on each of the bogies. The poles of each electromagnet will be in register with the two opposite vertical sides of the upper and lower continuous rails forming the rotor units, and an air gap is maintained between the poles of the electromagnets and the continuous rails. The air gap may be maintained by means of the wheels which engage the opposite vertical sides of the continuous rails being provided with highly pressurised pneumatic tyres. Thus these wheels serve the dual purpose of maintaining the air gap and acting as lateral guides for the vehicle or vehicles in the train. It should be noted that each vehicle making up the train may comprise any even number of bogies, and any even number of stator units, the units being arranged in diametrically opposed pairs.

As mentioned, any pitch which may occur is minimised by the resultant thrust acting through the loaded centre of gravity and parallel to the axis of the channel or conduit, and this may be further reduced by shaping the rails, i.e. the continuous rotor rails, so that they are cut back above or below the area matching the nominal stator position. Should the vehicle pitch, and thereby cause vertical displacement between the rails and the magnets of the stator units, forces will be generated tending to cause the stator units to return to their initial position, the position of minimum air gap between the rail and the stator magnets.

Alternating electric current, normally a three phase supply, is supplied to the stator units by means of live conductor rails mounted on, and insulated from, the lower horizontal face of the upper rotor rail, i.e. the upper continuous rail. Allowance will normally be made for vehicle sag by the spring loading of the pick-up shoes. The speed of the vehicles will be monitored by control of the voltage and the frequency of the supply current.

When the train is supported by means of an air cushion, each vehicle rides with its main wheels clear of the lower rail and with the magnets of the stator units in register with the side faces of the rotor rails. The pressure

of the air cushion is maintained in an area bounded by skirts at the front and rear of the train and the volume of air is kept to a minimum. This may suitably be effected by making the air cushion feed ducts take up the whole of the space between the vehicle floor and a line a few inches above the top of the lower rail. The spaces between the lower bogies may be used to house compartments for various facilities such as air conditioning plant, hydraulic equipment and control gear.

The parallel shelves which serve to confine the air cushion are at a height approximately level with the top face of the lower rail and extend into the channel or conduit so as to leave just sufficient clearance for the bogie magnets and side guidance wheels which, as mentioned above, may be provided with pneumatic tyres.

The air supply for the air cushion is generated by a multi-stage fan at the front of the train and passes through supply ducts running on either side of the bogies for the whole length of the vehicle. The supply ducts may support a number of nozzle segments, for instance of the order of five feet long, forming the ducts, the air flow, introduced through restrictor orifices, being directed to impinge in a direction downwards and inwards on to the shelf surfaces to provide a seal over the small gap between the nozzle mouth and the shelf. The segments, being individually free to move up and down relative to the vehicle, maintain their positions relative to the shelf surface as the vehicle is displaced.

The fan unit also passes air over the surfaces of the vehicle in such a way as to leave the air in front undisturbed and to restore atmospheric pressure at the rear with minimum loss of energy. This air may pass through ducts arranged beneath the train, and/or it may pass over the top and sides of the vehicles.

In a preferred embodiment of the invention, the wheel or wheels of the lower bogie ride along the upper face of the lower continuous rail. Alternatively, however, the bogie wheels may be arranged in pairs, one on either side of the lower rail, so that they may ride along the base mounting flange of the rail. With such provision, and the addition of further retractable and swivelling stabilising wheel units, the vehicles may be run off the tapered ends of rail terminations and be thereafter supported on a flat surface on such wheels. The lower mounting of wheels in this way allow for greater swivelling of the bogie and greater clearance between the air ducts and the floor of the conduit.

Each vehicle may also be provided with auxiliary wheels, which may be used in the case of a break-down in the air cushion or of the wheel or wheels riding on the lower rail. These auxiliary wheels may also be used to run vehicles off the track if required, and thus it is preferred to mount the auxiliary wheels on rotatable bogies.

So far the transport system has been described mainly in relation to the vehicles being housed in, and moving in, a closed tubular conduit. However there is no reason why it should be completely enclosed and of course it will be open at the stations, where the conduit will be cut down to allow for the transfer of passengers and freight. This will be in order so long as the conduit section is retained up to the height of the shelves, so as to maintain the air cushion when such is used. In another embodiment of the invention, the lower continuous rail may be situated in a channel, so long as the channel is of sufficient depth to retain the air cushion. In this embodiment the upper continuous rail may be supported by hoops or by hockey stick-shaped stanchions.

Vehicles may be withdrawn from the system at prepared areas. At these positions the tube wall is cut down to track level. Prior to reaching this withdrawal position the rotor rails are progressively narrowed to extinction, so that the vehicles may be withdrawn sideways, by means of the auxiliary road wheels mounted on rotatable bogies. On replacement of the vehicles, they will progress on their wheels until the rails again appear as narrow blades which widen to normal width. This arrangement allows for re-engagement of the riding and side guidance wheels which position the stator heads.

As with the conventional railway, points systems may be arranged for diverting vehicles onto other tracks but, because of the clearance necessary for the magnets of the stator units and the side guidance wheels at the side wheels of the rails, the shift of the loose rails must be large.

Also, because the lower rail of one track must cut through the shelf of the other and so leave a considerable gap, provision must be made for bridging and sealing the gap so as to retain the air cushion. Thus, on each points system the upper and lower rails will comprise movable segments connectable to segments of further rails in another rail track, and the air cushion retaining shelves will be cut away so as to accommodate the movement of the movable segments. Furthermore, the lower rail may be provided with a separate overlying rail portion pivotally attached to it, and shaped so as to seal off the channel containing this rail when the points system is operated, to retain the air cushion. The total movement of the points system comprises the shift of the connected movable segments of the lower rails, a similar shift of connected loose segments of the upper rails, and an appropriate swivelling of the separate overlying rail portion.

The continuous rails forming the tracks may be made of steel or an aluminium alloy, and so also may the vehicles themselves, although from the point of view of weight saving alu-

minium alloy is preferable for the vehicles. The outer tubular shell of the system may be of reinforced and/or prestressed concrete, and it is envisaged that two or more tubular conduits may be situated side by side or one on top of the other. It is also envisaged that the conduits may be used to support a motor roadway on top of them.

The invention also comprises a method of constructing a transport system which comprises supporting a gantry structure on wheels engaging with the stationary rails in a completed section of tubular conduit, projecting the gantry structure forward to the position slightly forward of where a pylon to support the next section of tubular conduit is to be situated, supporting the projecting end of the gantry structure, and constructing the tubular conduit from and around the gantry structure.

In this aspect of the invention, it is preferred to use a gantry which is adapted for the movement thereafong of trolleys, which trolleys will carry the necessary sections for constructing the conduit. The gantry, which itself rolls on the rails of the completed conduit, may be so shaped as to support channel section rails on either side of and at the top and bottom of it so that trolleys, having wheels engaging the channel rails, may be propelled along either side of the gantry. The gantry is also, preferably, adjustable so as to facilitate the building of curves, banking and gradient into the conduit.

Normally the conduit will be built up in half sections, and as the half segments are laid, they will each be joined to their mating half and to the previous construction. When all segments are in place, adjustment for conduit form may be made. When the new section of the conduit is completed the gantry will be uncoupled, serviced and moved forward in order to build the next section of the conduit.

The invention is illustrated by means of the accompanying drawings, in which

Fig. 1 is a diagrammatic sectional view of a transport system, showing a vehicle disposed within a tubular conduit, the components of the linear induction motors, the air ducts and a wheel riding along the upper face of the lower rail;

Fig. 2 is a view similar to that of Fig. 1, showing riding wheels riding, along the base mounting flange of the lower rail;

Fig. 3 is a diagrammatic side elevation of a vehicle in the tubular conduit of Figure 1 showing the fan system;

Fig. 4 is a perspective view of a lower bogie of the vehicle in Figure 1 showing the components of the stator unit in detail;

Fig. 5 is a diagrammatic perspective view of a section of an air duct;

Fig. 6 is a diagrammatic plan view of a points system;

Fig. 7 is a detail of Fig. 6;

Fig. 8 is a diagrammatic side view of a gantry structure; and Fig. 9 is a diagrammatic sectional view of the gantry in a tubular conduit, showing a movable trolley.

With reference to the drawings, a vehicle 1 travels through a tubular conduit 2 of trapezoidal cross-section and having a roadway 3 constructed above it. Pivotally attached to the top of the vehicle is a bogie 4 comprising the stator unit 6 of a linear induction motor, the rotor unit of which is formed by the continuous longitudinal rail 8 attached to conduit 2. Pivotally attached to the bottom of vehicle 1 is a bogie 5 comprising the stator unit 7 of a second linear induction motor whose rotor unit is formed by the continuous longitudinal rail 9. The vehicles move through the conduit by virtue of the electromagnetic coupling of the units to form linear induction motors. The way in which a linear induction motor functions is known, and will therefore not be described herein.

The bogie 5 comprises a number of pneumatically tyred wheels 10 which ride on the upper face of the lower rail 9 as illustrated in Figs. 1 and 4, and two pneumatically tyred wheels 10 riding on the base flange of the rail 9 in the embodiment illustrated in Fig. 2, and pneumatically tyred side guidance wheels 11 which engage the vertical faces of rail 9. The upper bogie 4 also comprises side guidance wheels 12, these engaging the vertical faces of rail 8. The wheels 11 and 12, as well as providing side guidance for the vehicle, provide the air gap between the magnetic heads of the stator units and the continuous rails forming the rotor units, and as is shown in Figure 4 four side guidance wheels are provided for each stator unit.

Figure 1 also shows ducts 13 for the air-cushion, these ducts having restrictor orifices 14 and terminating in nozzles 15. The air expressed from nozzles 15 impinges on shelves 16, which as shown are at approximately the same level as is the top horizontal face of rail 9.

Three phase alternating electric current is taken off live rails 17 mounted on and insulated from the upper rail 8. It will be noted that rails 8 and 9 are undercut as at 18, so that any pitch of the vehicle during movement will be lessened due to the tendency of the magnetic heads of the stator units 6 and 7, carried on the vehicles, to return to the position of minimum air gap.

Figure 3 shows the fan system embodied in the leading vehicle of the train, which fan system is designated generally 19. It consists of a primary fan system 19*a* which passes low pressure air through ducts 20 for discharge over the top and sides to the rear of the train, and a secondary fan system 21 which supplies the air to ducts 13 for the supporting air cushion. Both fan systems are driven by the electrically powered motor 22. It will be appreciated of course, that the ducts 13 and

20 move with the train. Leakage of air forming the air cushion is minimised by the provision of a flexible skirt 23 at the front of the train and a further skirt (not shown) at the rear thereof.

Figure 4 shows in detail the lower bogie 5 comprising the lower stator unit 7, the side guidance wheels 11 and the main riding wheels 10 of the embodiment shown in Figure 1. The boss, whereby the lower bogie is pivotally connected to the vehicle, is indicated at 24.

A section of the air cushion-providing duct is illustrated in Figure 5, which shows that the main duct 13 is connected to a number of individual duct segments 25 attached to each other by means of seals 26. Each segment 25 is attached to the main duct 13 via hinge 27 and air under pressure flows through the restrictor orifice 14, out of the nozzle 15, and impinges upon shelf 16.

Figure 6 illustrates a points system for diverting a train from one track to another, and shows the lower rail 9 and a branch rail 90. Movement of a train from left to right as shown and from rail 9 to rail 90 is accomplished by means of the movable connected rail segments 9*a* and 90*a*. When the rail segments 9*a* and 90*a* are in the position shown in the Figure, a train will move from rail 9 to rail 90. It will be seen that it is necessary to cut out certain segments of the shelves 16 to accommodate this movement, and so that the air cushion is retained a separate rail bridge 9*b* is provided on rail 9. This is shown in detail in Figure 7, and it will be appreciated that when the points system is in the position to move a train from rail 9 to rail 90, the rail bridge 9*b* pivots about the point 28 so that its top is flush with the shelf surfaces and it forms a bridge seal. Rail bridge 9*b* is normally part of rail 9, and in its normal position its top is flush with the remainder of the top of rail 9. A companion rail bridge 9*c*, which normally forms part of rail 90, performs a similar function to that of rail bridge 9*b*.

With reference to Figure 8, a gantry structure 29 is shown projecting from a completed section of conduit 2, the gantry structure running along and being supported by the rails 8 and 9. When the gantry structure has been projected to the desired length, it is supported by means of a strut 30, which may suitably be grouted to a concrete base just ahead of the site of the next permanent conduit support pylon 31. A trolley 32 carrying a section of conduit 33 is adapted to run along the gantry, and the conduit is constructed by building up these sections 33 from and around the gantry. As will be seen from Figure 9, the gantry moves between the rails 8 and 9 in a manner similar to that in which a train moves in the conduit. The gantry is provided with channel rails 34 and 35 in which the wheels 36 of the trolley run. As shown in the drawing, the trolley is provided with a jack system 37, which carries the necessary segments of conduit which are to be assembled. When the conduit section is complete, a superimposed roadway may be constructed from a series of beams laterally positioned on top of the conduit.

WHAT I CLAIM IS:—

1. A transport system comprising at least one vehicle, a lower continuous rail and an upper continuous rail vertically spaced apart and between which the vehicle is mounted for longitudinal movement, at least one centrally disposed lower bogie provided on the vehicle and having at least one wheel adapted to ride along the lower continuous rail and wheels arranged to engage opposite vertical sides of the lower rail to provide guidance for the vehicle, and at least one centrally disposed upper bogie provided on the vehicle and having wheels arranged to engage opposite vertical sides of the upper continuous rail to provide guideance for the vehicle, the lower and upper bogies being adapted to be coupled electromagnetically with the lower and upper continuous rails respectively when alternating electric current is supplied to the bogies or parts thereof to form linear induction motors for the propulsion of the vehicle.

2. A transport system as claimed in claim 1 wherein the vehicle or vehicles, when moving, is or are supported upon a cushion of air.

3. A transport system as claimed in claim 2 wherein the lower continuous rail is situated in a channel.

4. A transport system as claimed in claim 3 wherein the channel forms part of a tubular conduit, the lower and upper continuous rails being mounted on the inside surface of the conduit.

5. A transport system as claimed in claim 4 wherein the tubular conduit is circular or trapezoidal in cross-section.

6. A transport system as claimed in any of claims 2 to 5 wherein the vehicle or, if more than one vehicle is used, the leading vehicle, is provided at its front end with first fan means adapted to draw air from in front of it and pass the air through a duct or ducts extending beneath the vehicle or vehicles to provide the supporting cushion of air.

7. A transport system as claimed in claim 6 wherein a duct for the expulsion of air for the air cushion is situated on each side of the lower bogie or bogies.

8. A transport system as claimed in claim 6 or 7 wherein each duct comprises restrictor valves and air nozzle arms.

9. A transport system as claimed in claim 9 wherein each nozzle arm is flexibly sealed to adjacent nozzle arms.

11. A transport system as claimed in any of claims 6 to 10 wherein the vehicle or leading vehicle is provided with second fan means

to pass excess air to the rear of the vehicle or vehicles.

12. A transport system as claimed in any of claims 3 to 11 wherein the channel is provided with parallel shelves running its length.

13. A transport system as claimed in claim 12 wherin the parallel shelves are at approximately the level of the top face of the lower continuous rail.

14. A transport system as claimed in any of claims 2 to 3 wherein the vehicle or vehicles is or are provided with flexible skirts for further retention of the cushion of air.

15. A transport system as claimed in any of claims 1 to 14 wherein each linear induction motor is formed by means of an electromagnet of substantially horseshoe section provided on each of the bogies, each of the pole pieces of the electromagnet on the lower bogie facing one vertical side of the lower continuous rail and each of the pole pieces of the electromagnet on the upper bogie facing one vertical side of the upper continuous rail.

16. A transport system as claimed in claim 15 wherein the lower and upper continuous rails have their vertical sides so shaped as to match the shape of the pole pieces and to provide the maximum area of minimum air gap when the pole pieces are in vertical alignment with the vertical sides of the rails.

17. A transport system as claimed in any of claims 1 to 16 wherein points systems are interposed along its length.

18. A transport system as claimed in claim 17 as dependent upon any of claims 12 to 16, wherein at each points system the lower and upper continuous rails comprise movable segments connectable to further lower and upper continuous rails respectively, and the air-cushion retaining shelves are cut away so as to accommodate movement of the movable segments.

19. A transport system as claimed in claim 18 wherein at each points system the lower continuous rail is provided with a separate overlying rail portion pivotally attached to the lower continuous rail and shaped so as to seal off the channel containing the lower continuous rail when the points system is operated, to retain the air cushion.

20. A transport system as claimed in claim 4 wherein two tubular conduits are situated side by side.

21. A transport system as claimed in claim 4 wherein two tubular conduits are situated one on top of the other.

22. A transport system as claimed in any of claims 4, 20 or 21 wherein a roadway is disposed on top of the tubular conduit or conduits.

23. A method of constructing a transport system as claimed in claim 4 which comprises supporting a gantry structure on wheels engaging with the lower and upper continuous rails in a completed section of tubular conduit, projecting said gantry structure forward to the position slightly forward of where a pylon to support the next section of tubular conduit is to be situated, supporting the projecting end of the gantry structure, and constructing the tubular conduit from and around the gantry structure.

24. A transport system substantially as hereinbefore described with reference to Figures 1 to 7 of the accompanying drawings.

25. A method of constructing a transport system substantially as hereinbefore described with reference to Figures 8 and 9 of the accompanying drawings.

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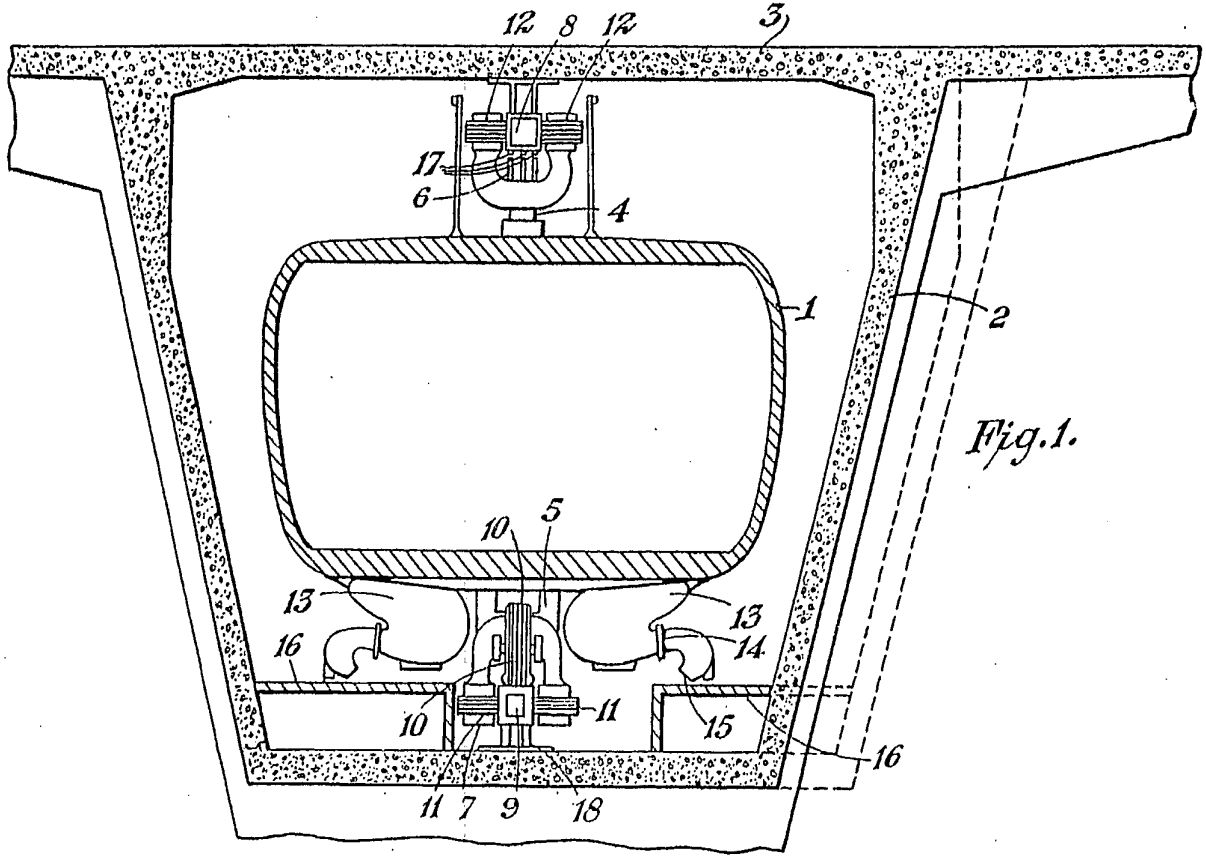

Fig.1.

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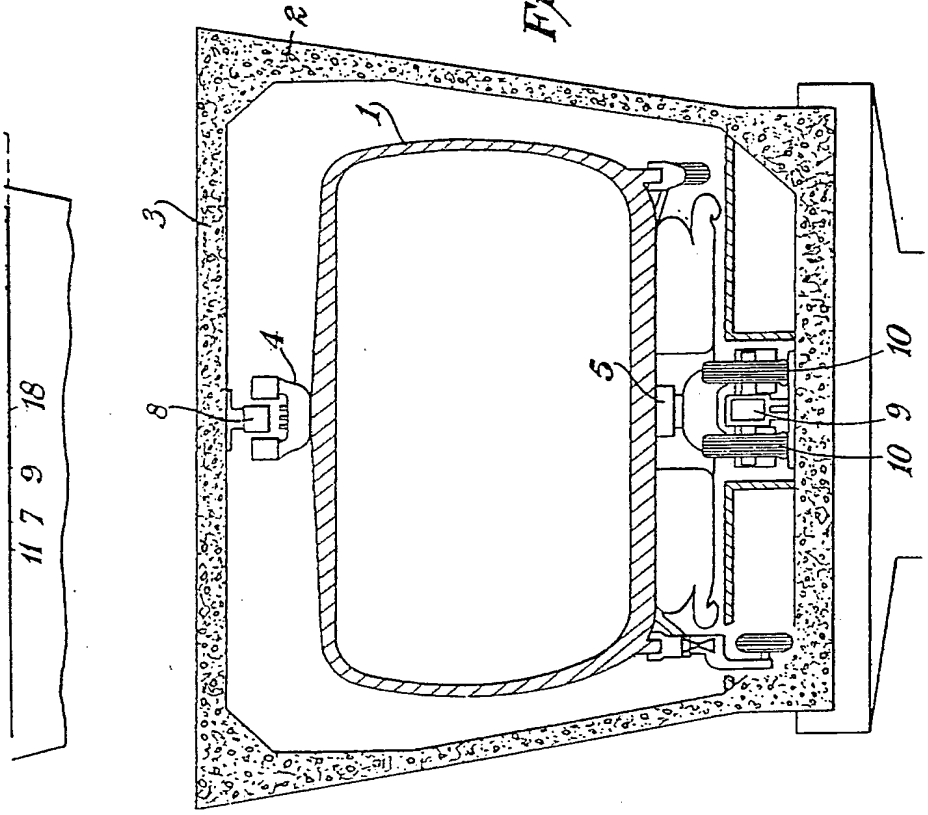
Fig.2.



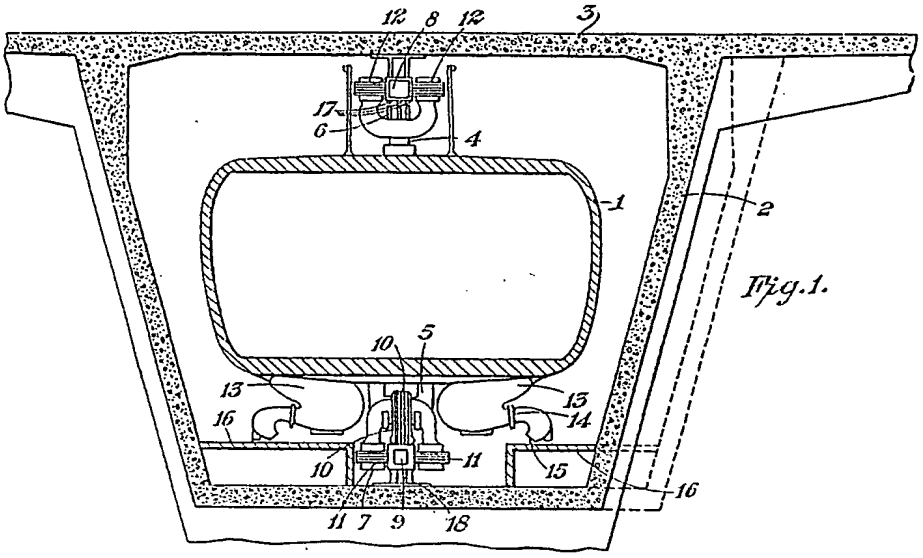


Fig.1.

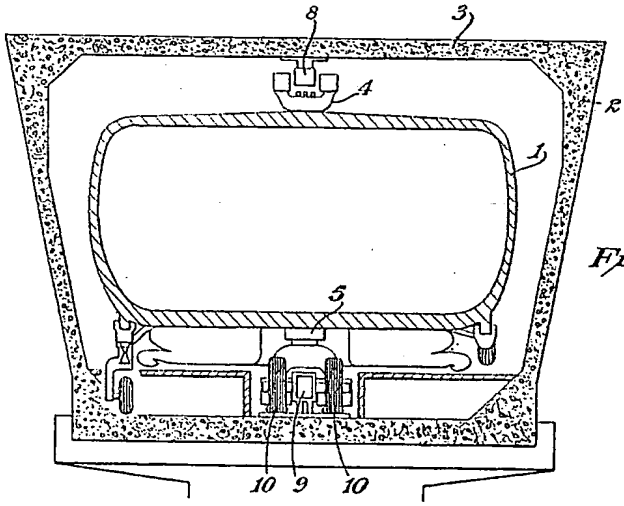


Fig.2.

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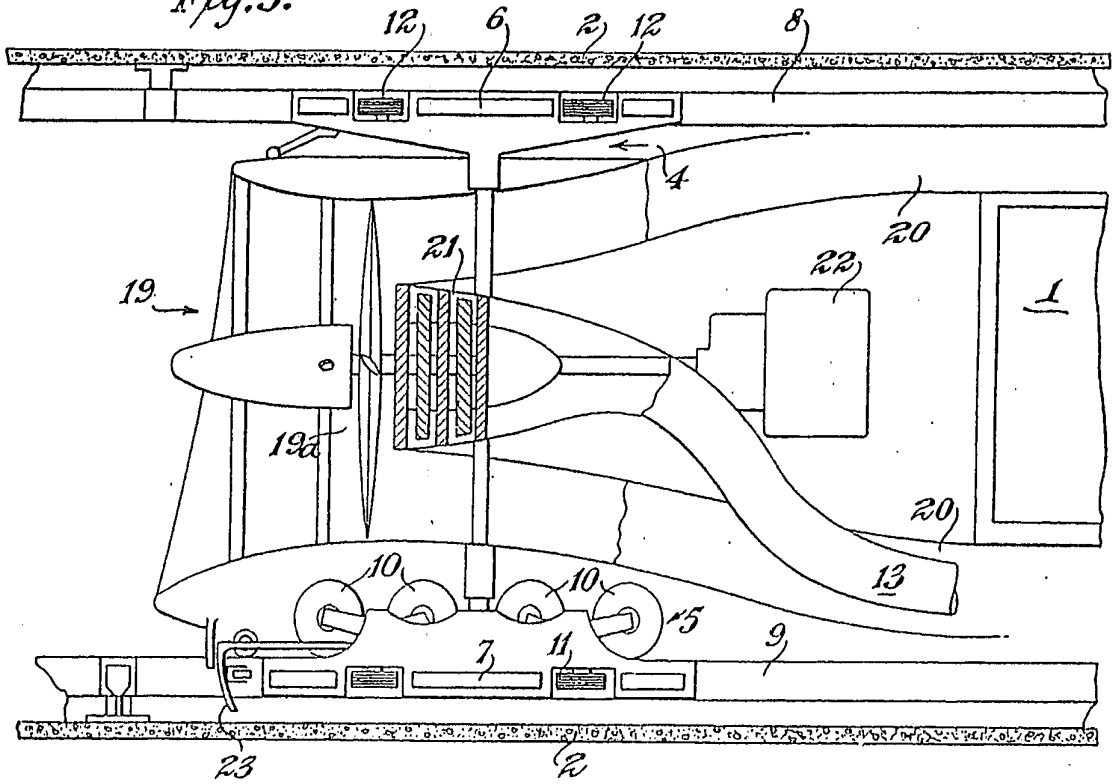
Fig.3.



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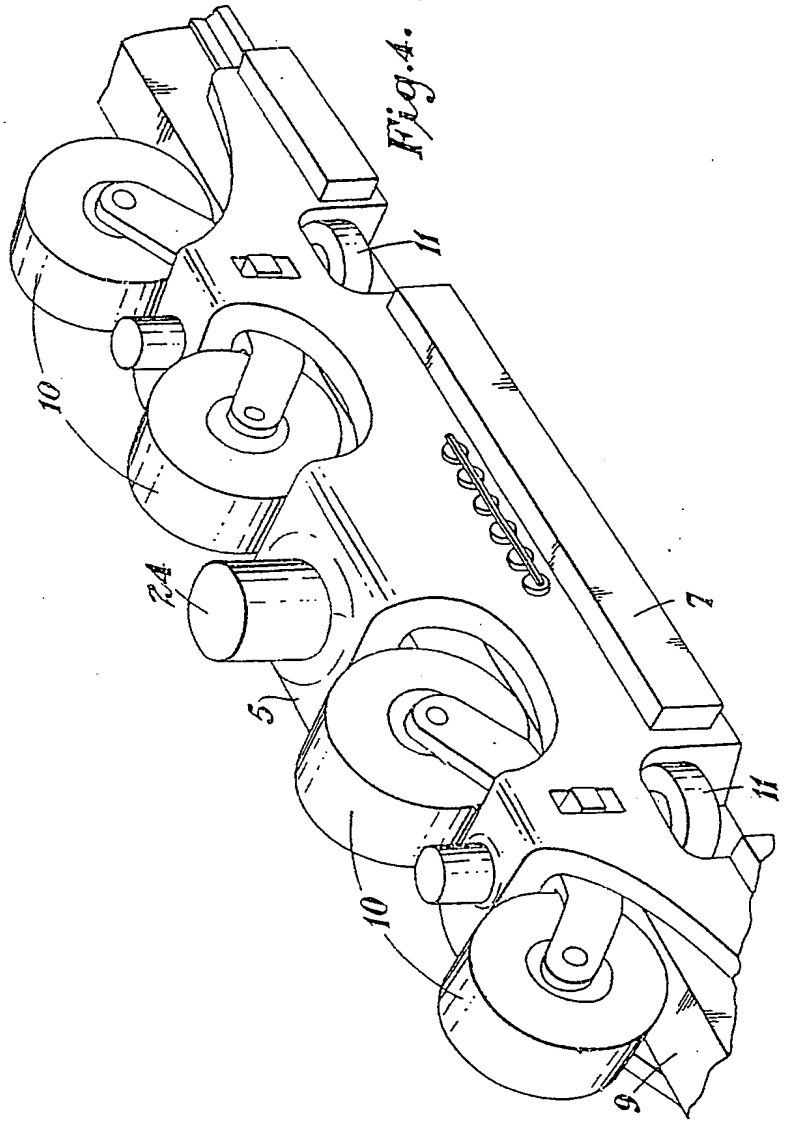
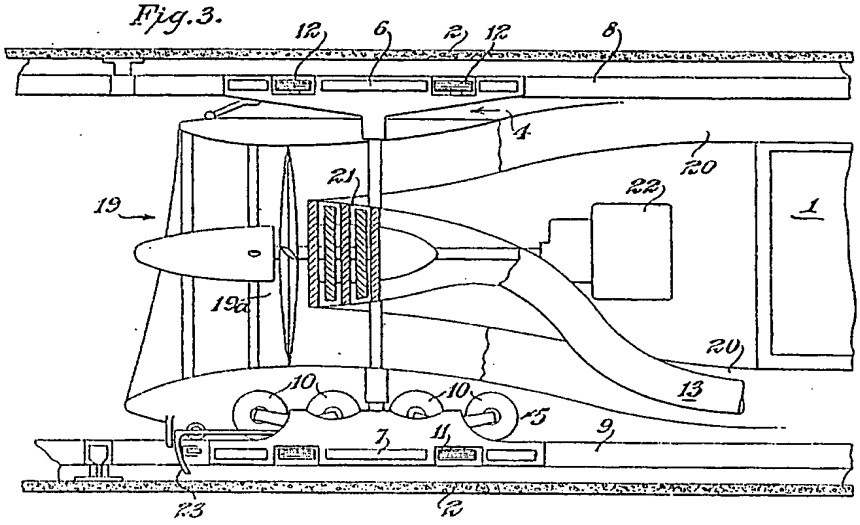


Fig.3.



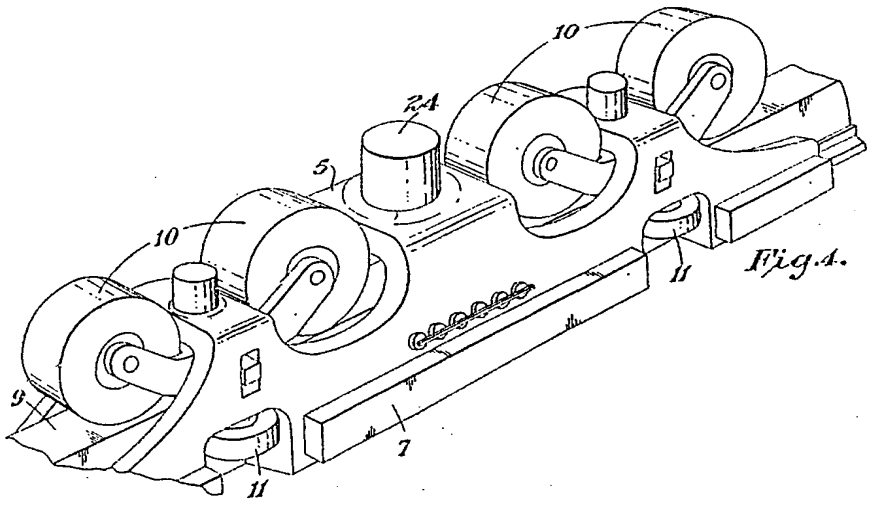


Fig.4.

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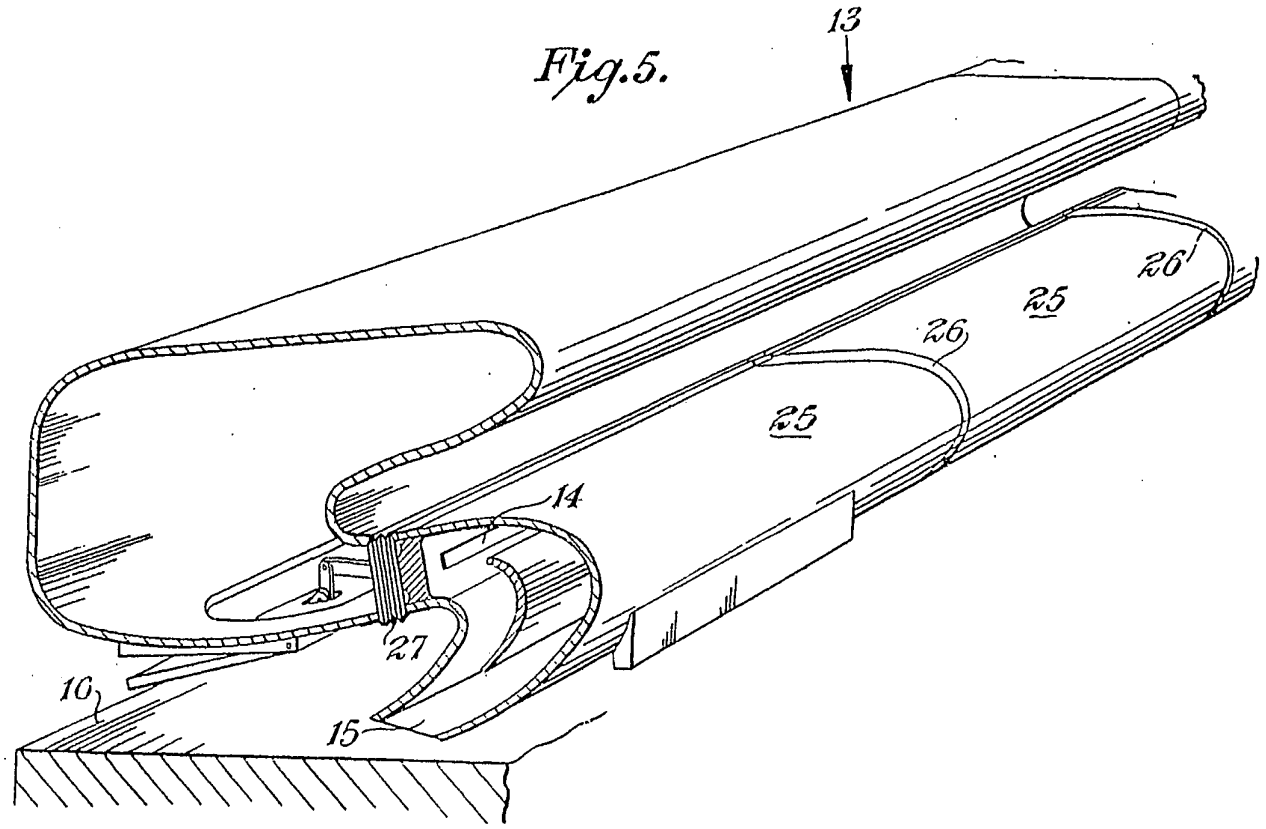
Fig.5.



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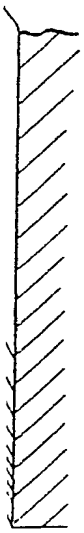

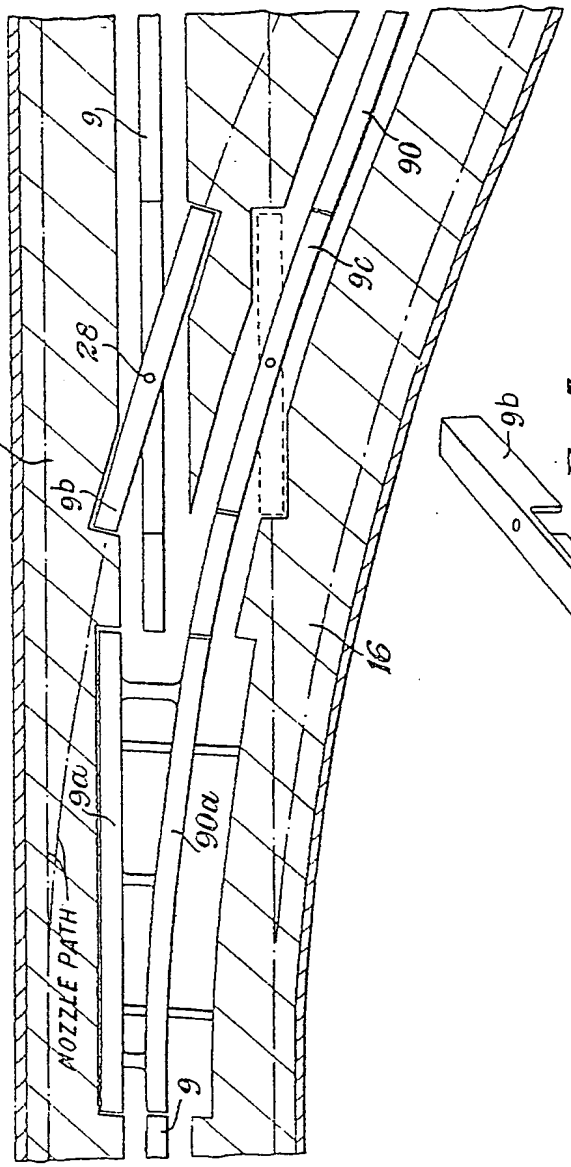

Fig. 6.

Fig. 7.

Fig. 5.

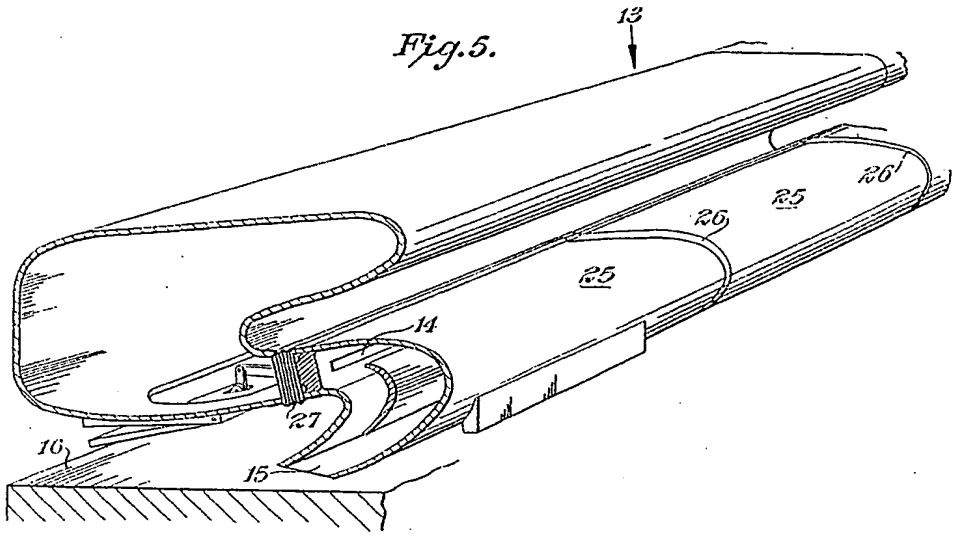

Fig. 6.

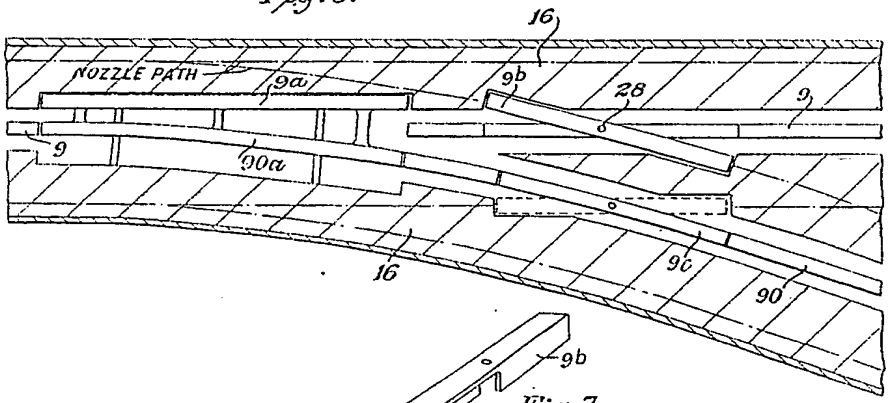

Fig. 7.

1104746 COMPLETE SPECIFICATION
8 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 5 & 6

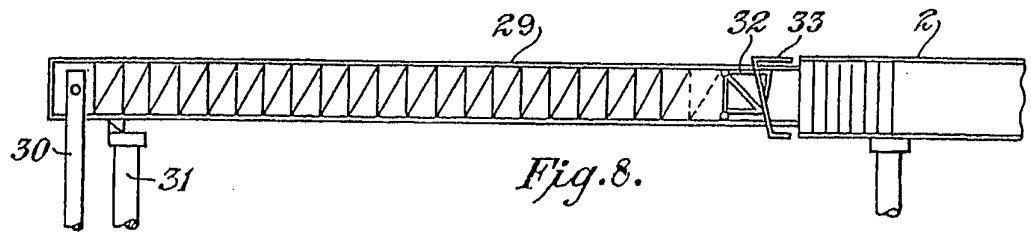

Fig. 8.

1104746 COMPLETE SPECIFICATION

8 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 7 & 8

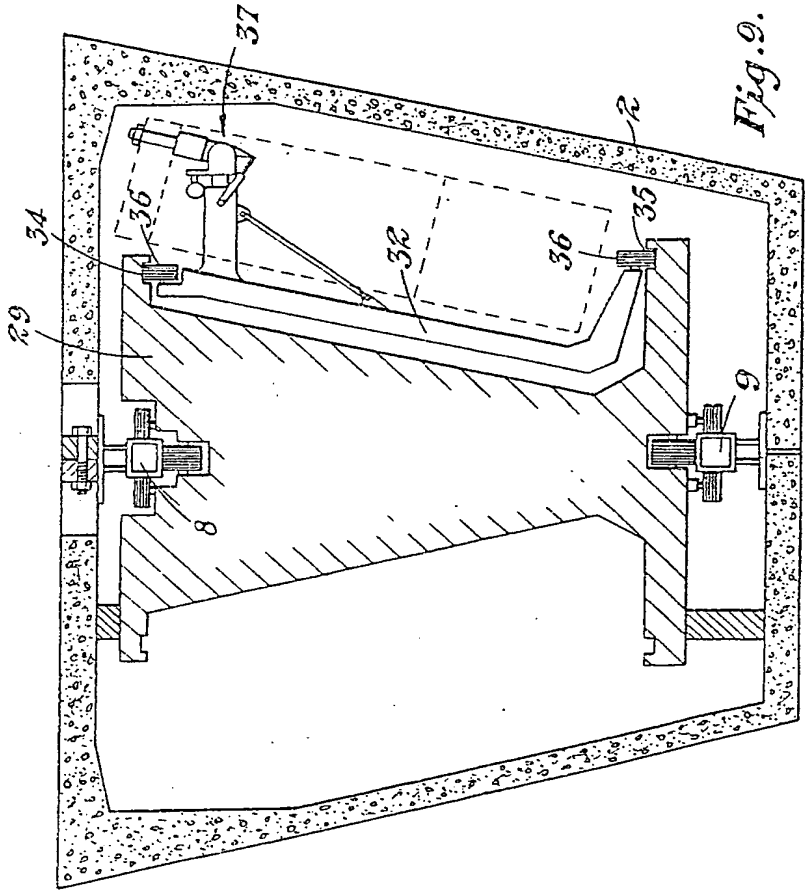

Fig. 9.

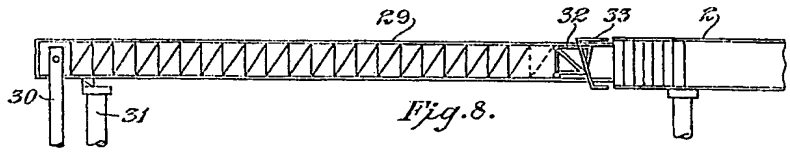

Fig.8.

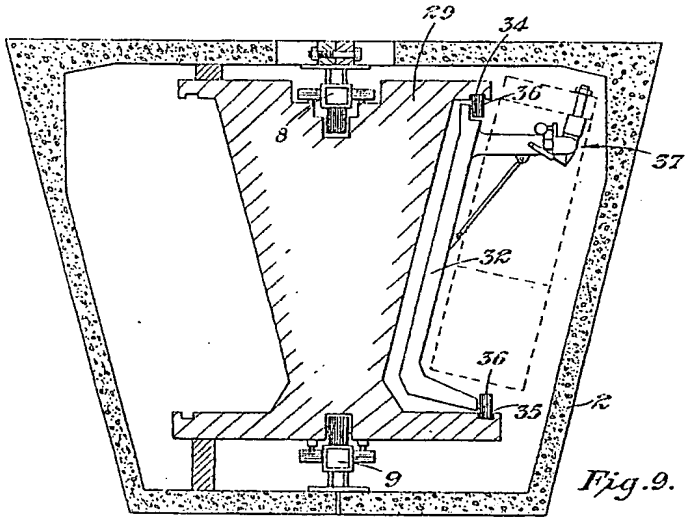

Fig.9.

1104746 COMPLETE SPECIFICATION
8 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 7 & 8